GRAFTING OF VEGETABLES IN ROMANIA

ALTOIREA LEGUMELOR ÎN ROMÂNIA

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Abstract. *Soil diseases and nematodes cause great damages to vegetable crops and represent some of the most limiting factors for farmers' income. Their global management was based on the soil's fumigation with methyl bromide before planting, a compound whose elimination procedure was initiated by the Protocol from Montreal (1992), due to its dangerous effects on the environment. Romanian Government decided to eliminate gradually the use of methyl bromide since 2005. In the recent years, the research has focused on investigationthe alternatives to methyl bromide for prevention and combating the soil diseases and nematodes, particularly in protected vegetable crops. These alternatives were based both on the use of other chemical compounds and some non-chemical methods (soil disinfection with steam, use of green houses, culture practices, improving the resistance of plants). The purpose of this paper is to present the actual achievements to in grafting of vegetables in Romania.*
Key words: *scion, rootstock, marketable production, commercial quality, nutritional value, soil diseases*

Rezumat. *Bolile de sol şi nematozii produc mari pagube în culturile de legume și reprezintă unii dintre cei mai limitativi factori ai veniturilor fermierilor. Gestionarea lor la nivel mondial a fost bazata pe fumigația solului înaintea plantarii cu bromură de metil, un compus a cărui procedură de eliminare a fost inițiat prin Protocolul de la Montreal (1992), datorită efectelor sale periculoase asupra mediului. Guvernul României a decis să elimine treptat utilizarea bromurii de metil începând cu anul 2005. În ultimii ani, cercetarea s-a concentrat pe investigarea alternativelor la bromura de metil pentru prevenirea şi combaterea bolilor de sol şi a nematozilor, în special în culturile protejate de legume. Aceste alternative s-au bazat atât pe utilizarea altor compuși chimici cat și pe unele metode nechimice (dezinfectia solului cu abur, solarizarea, practicile culturale, îmbunătățirea rezistenței plantelor). Scopul acestei lucrări este de a prezenta realizările la zi în domeniul altoirii legumelor din România .*
Cuvinte cheie: *altoi, port-altoi, productia vandabila, calitatea comerciala, valoarea nutritiva,boli de sol*

INTRODUCTION

Abiotic environmental factors from protected areas offer favorable conditions for many species of pathogens and pests which cause high production damages. Soil diseases and nematodes have a particularly destructive action in

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vegetable crops and represent one of the major factors of limiting farmers' income, making necessary to adopt soil disinfection practices, or other technological methods (Gullino *et.al.,* 2003). Before 2002, the most common methods of soil disinfection in Romaniangreenhouses were soil sterilization by steam and use of methyl bromide (107.72 tones of methyl bromide in 2003), (Bogoescu *et al.,* 2005). Traditionally, the greenhouses were built around the for thermalpower plants from main cities,using the hot water produced by them for heating.

Methyl bromide was until now and remained perhaps the only fumigant that is efficient against pathogens, nematodes, weeds, insects and rodents. But, according the Montreal Protocol (1997) use the methyl bromide (a compound which is applied to soil by fumigation for plant protection) leads to ozone's layer reduction in the stratosphere and is forbidden in Romania since 1 January 2005. In this situation, beginning with 2002 there was performed research that aimed to establish alternatives to the use of methyl bromide in Romanian horticulture. Grafting the high quality and productivity of varieties on rootstocks that are resistant to diseases and pestsfrom the soil, it is a method known for a long time, but has been improved and has spread rapidly in the recent years (Bausher and Chellemi, 2001). Gripping of a grafted plant on the wild type of rootstock which has a a root robust system and strong resistance to pests and diseases ,a cultivar with remarkable technologicaland senzorial qualities, all that lead to asuperior tolerance of the grafted plant to the less favorable conditions of soil and environmental (Edelstein, 2004; Oda, 1993).

However, the most important result of the grafting process of vegetables is given by conferring the high resistance to soil diseases (such as *Fusarium, Verticillium)* or nematodes (Bogoescu *et al.,* 2005).

The first grafting of vegetables were performed in Romania in the 70s oflast century. Further, until 2001 this activity has never took place. Beginning with 2002 were started researches in this area of horticulture, under a project funded by UNIDO. The research aimed to establish alternatives to the use of methyl bromide in Romania; the biological alternatives for the vegetable's grafting were recorded similar results to those found in many chemical alternatives.

By this reason, the research have been developed as far as in presentit has been established the production technologies and cultivationof grafted seedlings for tomatoes, eggplants, melons and water melons, cucumbers. Since 2015 have been initiatedthe necessary research for specification the technology for obtaining the grafted seedlings and cultivation of vegetables from pepper's group.

As result of the developed researches and dissemination ofobtained results, thegrafted seedlings technology extendedtomany private manufacturers and watermelon's culture it is realizing in a proportion of 80% by using grafted seedlings. Only in the village Dăbuleni, Dolj county–with tradition in melon's cultivation - were purchased in 2014 over two million of grafted seedlings of melons from import.

The aim of this paper is to present some results obtained during development the researches in the field of vegetable's grafting, in Romania.

MATERIAL AND METHOD

The researches were organized during 2008 – 2013 on tomatoes, cucumbers and watermelons cultivated in demonstration station of HORTING Institute, in order to identify new alternatives to use the methyl bromide in Romania.

The efficiency of the chemical alternative with methamsodium (100 ml/m²), respectively the non-chemical alternative, vegetable's grafting, were tested and compared with the results obtained after soil disinfection with methyl bromide (75 g/m²), used as control variant.

V1= methamsodium

V2= grafted plants

V3=methyl bromide

The variants, with an average surface of 900 m^2, were organized by the method of random blocks, each experimental variant having three replicates.

The soil disinfectants were applied through a dripping irrigation system. Soil disinfection was done according to the specific climate conditions, respectively to a temperature over 15ºC at a 10 cm depth in the soil. The soilhas been covered with polyethylene film (4 m width; 0,11 mm thickness; gas-proof). The waiting time was 8 days for methyl bromide and 21 days for methamsodium.

The Mondial F1(Enza Zaden) tomatoes hybrid was grafted on the Beaufort (De Ruiter Seeds) resistant rootstocks; the Mathilde F1 (Royal Sluis, Holland) cucumber hybrid was grafted on the Shintoza *(Curcubita maxima x Cucurbita moschata)* resistant rootstock and the Cicerio F1 (Ergon Seed) watermelon hybrid was grafted on the ES30900 (Ergon Seed) resistant rootstock. The grafted plant culture shad the following densities:

Grafted tomatoes = 18000 plants/ha, realized by 2 stems

Grafted cucumber = 32.000 plants/ha

Grafted watermelons = 3000plants/ha

There were done observations and determinations regarding the influence of soil disinfections treatments and the use of grafted plants, about:

- marketable production
- appearance of first crop
- quality of fruits
- nutritional value of fruits
- frequency of soil diseases and nematodes:

• corky root induced by *Pyrenochaeta lycopersici* - tomatoes

• *Fusarium oxysporum f. sp. cucumerinum* – cucumbers and watermelons

• incidence of nematode's attack on roots

The presence of galls induced by nematodes from the *Meloidogyne* genus was visually assessed at the end of deforestation of plots, on 15% of the plants harvested from the middle of the plots. The following indexing scale was used (Lamberti and Di' Vito):

• 0 = no galls

• 1 = very slight infection, not widespread galls, presence of 1-5 galls located only on few roots

- 2 = slight infection, rare widespread galls, presence of no more than 20 galls spread on roots system
- 3 = medium infection with widespread galls, more than 20 revealed galls and well spread on all roots system;
- 4 = strong infection, roots system integral affected and deformed due the presence of big galls on the main roots;
- 5 = very strong infection, roots system completely affected and totally deformed due to the presence of big galls, absence of capillary roots.

The root's index (0-5) was calculated as follows:

$$\frac{\sum \text{nematode's index of all plants}}{\text{Number of plants}}$$

For the pathogens determined there were calculated the frequency, by the following formula:

F% = Nx100/Nt, where:

N =number ofattacked plants

Nt= total number of analyzed plants

Data's analysis was performed on the average data recorded for the examined species of vegetables (tomatoes, cucumbers, watermelon).

Statistical analysis of results was performed by Duncan's test.

RESULTS AND DISCUSSION

In order to reveal the influence of different alternatives regarding themarketable production,datawere collected and presented inTable 1. The use of grafting plants conducted to a significant higher production comparing with soil disinfection with methamsodium, with over 8,5% at tomatoes and cucumbers, respectively 95,1% at water melons. The obtained results showed a significant difference at the variant with grafted plants comparing with the method by soil disinfection with sodiummetham (over 18,70%). At the same time, there were no registered significant differences between the grafted plants production and the soil disinfection variant, using methyl bromide (witness variant), just in watermelons culture where the production was with 54% higher.

Table 1

Influence of vegetable's grafting and some chemical methods of soil desinfection on marketable production (t/ha)*

Culture	Sodium metham	Grafted plants	Methyl bromide
Tomatoes	114 b	124a	128a
Cucumbers	47a	51a	55a
Water melons	48b	82a	53b

*Into a row, the values written with the same letter do not present significant differences after Duncan test, for p=5%.

Data presented in Table 2 refers at experiments which followed the influence of variants which were studied on the earliness grade of vegetables. The observations and determinations followed the registration of the crop's earliness,

expressed by first harvesting day, respectively the number of days between plantation and harvesting. Recorded data reveals a delay for first harvesting in grafted plants variant with 5-7 days, comparatively with first harvesting day at non-grafted plants situation, which were planted in disinfected soil with soil fumigants. The differences obtained between the disinfection method by soil fumigation and grafted plants method was statistical ensured for p=5%, by Duncan test.

Table 2

Influence of vegetable's grafting and some chemical methods of soil desinfection on earliness (nr.days)

Culture	Methamsodium	Grafted plants	Methyl bromide
Tomatoes	81a	88b	80a
Cucumbers	32a	37b	32a
Water melons	78a	85 b	77a

Into a row, the values writen with the same letter do not present significant differences after Duncan test, for p=5%.

In Table 3 are presented datawhich refersto the influence of alternative methods comparing with methyl bromide, on the percentage of first class fruits. Fruit's quality was assessed according to the quality standards for fresh fruits and vegetables: SR 1421/2001 for tomatoes, SR 1416/2003for cucumbers and SR 3654/2003 for watermelons. The analyzed data showed an improvement of commercial quality at grafted plants, respectively at first class fruits, in percentage of over 84,4% at tomatoes and cucumbers and over 93% at water melons, comparatively with non-grafted plants, where depending of variety and treatment method, the percentage of first class fruits never exceeding values between 69,9–81,1%; the differences between the disinfection methods by fumigation and use of grafted plants are statistical ensured for p=5%, by Duncan test.

Table 3

Influence of vegetable's grafting and some chemical methods of soil desinfection on quality (%)

Culture	Sodium metham	Grafted plants	Methyl bromide
Tomatoes	80,7b	84,6a	81,1ab
Cucumbers	78,4b	84,4a	78,3b
Water melons	69,9c	93,1a	78,8b

Into a row, the values writen with the same letter do not present significant differences after Duncan test, for p=5%.

Regarding the nutritional value's evaluation there were made determinations of soluble dry substance and soluble carbohydrates content. Determinations were made on standard samples of 6 melons /sample and 3 kilograms/sample of tomatoes and cucumbers. Samples were taken from the mass of product during two harvests. The biochemical analysis were realized by refract

metric method for soluble dry substance (STAS 5956/1991) and respectively, by Bertrand method for soluble carbohydrates content.

The results shown represent the average of both harvests (Table 4).

Table 4

Influence of vegetable's grafting and some chemical methods of soil desinfection onnutritional value (%)

Culture	Sodium metham		Grafted plants		Methyl bromide	
	Soluble substance	Soluble carbohydrates	Soluble substance	Soluble carbohydrates	Soluble substance	Soluble carbohydrates
Tomatoes	5,6a	4,18m	5,4a	3,99m	5,6a	4,09m
Cucumbers	4,6a	3,81m	4,4a	3,72m	4,7a	3,94m
Water melons	6,5a	5,84m	6,2a	5,75m	6,4a	5,78m

Into a row, the values writen with the same letter for soluble substance (a..b) and soluble carbohydrates(m…n)do not present significant differences after Duncan test, for p=5%.

The obtained results showed a slight decrease regarding the value of the two indicators of nutritional value at the variant in which were used grafted plants of any variety. The differencesregistered, between the soil disinfection by fumigation variant and grafted plants cultivation, are not relevant statistically.

Based on observation made "in vitro" culture there were identified soil pathogens as *Pyrenochaeta lycopersici*at tomatoesand *Fusarium oxysporum f. sp. cucumerinum* at cucumbers and water melons. The data revealedthe efficiency of soil disinfection treatments with methyl bromide and methamsodiumand in the same time the tolerance and resistance of grafted plants to soil diseases (table 5). The frequency of the attack of *Pyrenochaeta lycopersici* fluctuated between 1,39% at tomatoes planted in disinfected soil with methyl bromide and 1,49% at grafted plants. At soil pathogen *Fusarium oxysporum f. sp. cucumerinum* was registered a frequency of attack of 2,29% to cucumbers planted in disinfected soil with methyl bromide and 2,43% at grafted cucumbers; a similar curve was registered at the water melons culture, too.

Table 5

Influence of vegetable's grafting and some chemical methods of soil desinfection onfrecvency of soil disease (%)**

Culture	Sodium metham	Grafted plants	Methyl bromide
Tomatoes	1,41a	1,49a	1,39a
Cucumbers	2,34m	2,43m	2,29m
Water melons	0,91m	0,87m	0,81m

*Into a row, the values writen with the same letter ("a for*Pyrenochaeta lycopersici) and („*m" for*Fusarium oxysporum)* do not present significant differences after Duncan test, for p=5%.
** *Pyrenochaeta lycopersici*to tomatoes
*Fusarium oxysporum f. sp. cucumerinum*to cucumbers and water melons

Although was registered a higher frequency of the soil diseases on grafted plants – indifferently of variety- the differences are statistical found in experimental error, not being registered significant differences after Duncan test, for p=5%.

Regarding the alternatives effect to nematode attack (*Meloidogyne* spp.), the results at the moment of removing the experimental variants are shown in Table 6.

Tabel6

Influence of vegetable's grafting and some chemical methods of soil disinfection on the incidence of nemathodes attack (%)**

Culture	Sodium metham		Grafted plants		Methyl bromide	
	Root index²	Frecvency[1]	Root index²	Frecvency[1]	Root index²	Frecvency[1]
Tomatoes	1,8	3,1b	1,9	3,1b	0,9	1,1a
Cucumbers	1,7	2,9b	1,8	3,3b	0,8	0,6a
Water melons	1,2	0,9a	1,2	1,1a	1,1	0,8a

Into a row, the values writen with the same letter do not present significant differences after Duncan test, for p=5%.

[1]Average of percentage of infected plants evaluated with all plants, collapsed, but still alive at the end of cycle.

² Galles Index of nemathodes on the rooths, after Lamberti and DI Vito: variation interval 0:5

It is observed a decrease of frequency of nematode'sgalls in case of variants where the soil was disinfected with methyl bromide (0,6 – 1,1%)) and methamsodium (0,9 – 3,1%). The frequency of nematode's attack registered to grafted plants was (according to varieties) between (1,1 - 3,1%).

In the same time, the index regarding the galls on roots registries a variation from 0,8% in the situation of treatment with methyl bromide (water melons) until 1,90 at grafted tomatoes. The analysis of data confirms the tolerance effect of grafted plants on nematode's attack *Meloydogine* spp. The obtained results do not shows significant statistical differences between chemical alternatives (sodium metham) and use of grafted plants.

CONCLUSION

1. Results revealed that in Romanian conditions can be successfully used both chemical method (methamsodium) and non-chemical method of grafted plants, for preventing diseases of plants caused by soil pathogens and pests

2. Grafting of vegetables leads to increasing of marketable production, of commercial quality and do not affects the nutritional value of plants

3. Obtained results show as appropriate the following alternatives at methyl bromide:

• Chemical method: fumigation with methamsodium

• Non-chemical method: grafted plants method

4. Between the non-chemical methods the benefits of grafted plants in vegetable's cultivation overcome the possible risks.

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